THE CLOUD RING ON BUFFALO MOUNTAIN, COLORADO.

By Prof. R. DEC. WARD, Harvard University, dated August 3, 1903.

In his Philosophy of Storms (1841, foot note, pp. XXIV and XXV), Espy quoted a letter from Caleb Williams, dated December 20, 1839, describing the curious cloud which he had observed in 1815 on the island of Hawaii. This cloud, due to the combined action of the diurnal sea breeze and the upcast valley breeze, was observed to form soon after the sea breeze set in, at about 9 in the morning, and later surrounded "The lofty conical mountain in that island, in the form of a ring, as the wooden horizon surrounds the terrestrial artificial globe." The mountain stood in bold relief, and from where the ship lay the summit could always be seen above the cloud. This reference to the cloud ring of Hawaii has often been quoted, and the cloud has become, as it were, a "stock example" of this kind of thing.

One of the writer's students during the past winter (Mr. L. V. Pulsifer, of the class of 1903, HarvardCollege), contributed to the discussions on clouds which were held by the class in meteorology, the following account of a cloud ring which he had observed in Colorado during the summer of 1901. As these are peculiarly interesting clouds, the description may be worth quoting in the columns of the REVIEW.

Buffalo is a huge, roughly conical mountain, situated near the town of Dillon, Summit County, Colo. The general valley level at this point is about 8000 feet above the sea, and the mountain has a height of a little over 14,000 feet. I spent the summer of 1901 at Dillon, and on hot, still days noticed the formation of a cloud ring on Buffalo. This ring appeared at about noon, and was always at about the same height on the mountain side, roughly between timber line and snow line. The ring was not always perfect, but there was usually an incomplete ring even when the whole circuit was lacking. On the days when the ring was incomplete, the patches of cloud which did form were over the snow-filled gulches on the mountain side. During the middle of July and the first part of August the ring was best shown. * * * I do not recall whether this cloud ring ever reached a sufficient size to cause precipitation. It usually disappeared late in the afternoon.

ON CURVES REPRESENTING THE PATHS OF AIR IN A SPECIAL TYPE OF TRAVELING STORM.

By W. N. SHAW, Sc. D., F. R. S., Secretary of the Meteorological Council, dated August 25, 1903.

The instantaneous motion of air in a traveling storm may be regarded as approximately tangential to a series of concentric circles described about the barometric minimum as centre and representing isobaric lines. In any actual case there may be more or less "incurvature" of the air so that the lines of instantaneous motion are spirals instead of circles, and cross the isobars inwards. Moreover, in reality the isobaric lines themselves may be only more or less rough approximations to circles.

If the center of the storm (the barometric minimum) travels, the actual path of an isolated mass of air will be that described by a point which rotates with appropriate incurvature about a moving center. The real path will thus be a curve of no simple type and it will vary according to the speed at which the center travels. It can not be arrived at by superposing upon a simple rotational or spiral motion, a motion of translation equal to that of the center, because such superposition would alter the distribution of instantaneous velocities which represents the real instantaneous motion.

It is not difficult to calculate the actual paths for a special type of traveling storm making certain assumptions as to the velocities of the wind in different parts of the storm and the velocity of the center. As there are two kinds of motion to be considered, namely, that of the center, and that of the air masses, I propose, in order to avoid confusion, to limit the use of the word path to the motion of the center and to call the lines along which air travels "trajectories" of air.

The special case I propose to deal with is that in which the speed of the air is uniform over the area of the storm, although the direction varies from point to point. I shall also suppose the isobars to be true circles and the wind directions tangential to the isobars. Lastly the center will be regarded as describing a straight path with the same speed as the wind at any point. Whether this ideal state of things represents a possible reality is a matter for subsequent consideration.

Upon the hypothesis laid down, a "trajectory" is the curve described by a point rotating with uniform linear speed about a center moving with the same speed in a given direction. Take the path of the center as the x-axis of Cartesian coordinates and denote by θ the angle between the tangent to the trajectory and the positive direction of the path. The expression of the kinematical conditions must represent the fact that the center of curvature lies on the axis of x and moves along it with the same speed as the point along the trajectory. Expressing this condition we get the equation

$$y \sec^2 \theta \frac{d\theta}{ds} + \sec \theta = 1.$$

The same equation is obtained by equating the step along the curve to the step of the foot of the normal along the axis. Integrating the equation we get

$$y = \frac{c \cos \theta}{(1 - \cos \theta)},$$

c being an integration constant.

This equation represents a curve (see fig. 1) with a double

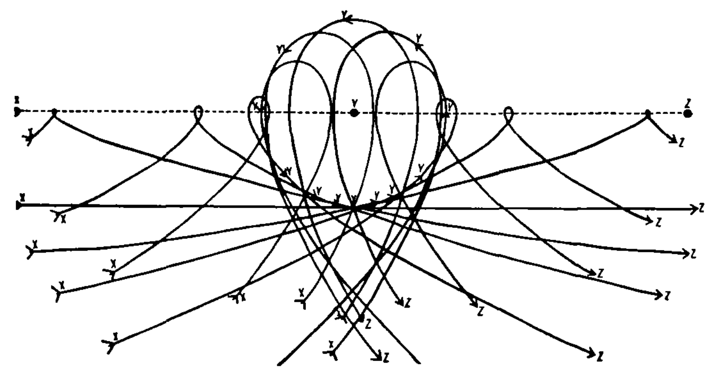

FIG. 1.—Calculated trajectories for the motion of air in a traveling circular storm when the velocity of the center is numerically equal to the wind velocity (assumed uniform) in the storm. XX. Initial positions of a series of particles and of the storm center. YY. Simultaneous position of the same particles when they lie on a circular isobar. ZZ. Final positions of the same particles and of the storm center.

point and a symmetrical loop above it. Taking a to be the ordinate of the top of the loop ($\theta = 180$), we get $c = -2a$ and $y + 2a \cos \theta / (1 - \cos \theta) = 0$ as the equation to the curve.

Substituting for $\cos \theta$ and integrating again we get

$$(a - y)\,(2a + y)^2 = 9\,ax^2$$

for the Cartesian equation of the curve when the axis of y is the line of symmetry of the loop.

The series of curves thus obtained for the trajectories is that represented in fig. 1; the intercepts on the axis of x are $\pm\, 2 / 3a$, and on the axis of y, a, and $2a$, representing the top of the loop and the double point, respectively. The curves of the family are similar in shape and are derivable one from the other by altering proportionally all linear dimensions. The one exception is the limiting case when $a = 0$ when the curve becomes a straight line parallel to the axis of x at an arbitrary distance from that axis and would represent the obvious result of a wind traveling parallel to the path of the storm at a fixed distance from the path.

It will thus be seen that the trajectories of air forming a revolving storm under the conditions described are widely different from the circular form represented by the isobars